Context Communications

# Certification

I, Alex Kent, a professional translator, hereby certify that the attached English document, Publication of an Unexamined Patent Application 07-185268, is a true and faithful translation from the Japanese language.

By Alex Kent Sept 4, 2004

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# (54) Title of Invention: HOLLOW FIBER FILTER MEMBRANE ELEMENT AND MODULE

(57) Abstract

**Purpose**

To provide a hollow fiber filter membrane element and module with a marked increase in the recovery of filtering capacity and enhanced maintenance properties in a hollow fiber filter membrane element that filters liquids containing fine particles and suspended materials.

**Constitution**

A hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air

inlet pipe in the central part of the hollow fiber membrane bundles, and in which there are inlet air jet orifices from the outside formed in the lower half of the total length of the element.

**Claims**

**Claim 1**

A hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air inlet pipe in the central part of the hollow fiber membrane bundles, and in which there are inlet air jet orifices from the outside formed in the lower half of the total length of the element.

**Claim 2**

The hollow fiber filter membrane element recited in Claim 1 wherein the air jet orifices are holes provided in the lower surface of the air inlet pipes.

**Claim 3**

The hollow fiber filter membrane element recited in Claim 1 wherein the air jet orifices are provided in the air diffuser plate or air diffuser tube that connects effectively perpendicularly with the air inlet pipe.

**Claim 4**

The hollow fiber filter membrane element recited in Claim 1 wherein an air jet means is provided in the lower end plate, and in which there is an air-tight connection between this air jet means and the air inlet pipe.

**Claim 5**

A hollow fiber filter membrane module in which the element recited in Claim 1 is fitted into a module container provided with a raw water orifice, an air relief orifice, a drain orifice, a filtered water orifice, and an air inlet, with sealing material interposed with this container.

**Claim 6**

The hollow fiber filter membrane module recited in Claim 5 is provided with an air jet orifice at the bottom of the module container to enable scrubbing air to be introduced into both the element and the bottom of the module container when cleaning by air scrubbing.

0001

**Industrial Field of Use**

This invention relates to hollow fiber filter membrane elements and modules used for filtering operations.

0002

**Prior Art**

There are typically large quantities of SS[1], fine particles, dirt, microorganisms, algae, etc. in industrial water. Continued use of such water can result in clogged pipes, bacterial propagation, buildup of scale in lines, and other problems. Typically, a variety of methods, including sand filtration, condensation filtration, cartridge filtration, and others have been used to remove these materials from the water. A new method that has recently been used in place of these filtration methods has been the application of porous hollow fiber membranes. In recent years, there has been a rapid increase in the use of hollow fiber membranes for water treatment and filtration, and the areas in which this technology is applied are growing from year to year.

0003

In filtration with hollow fiber membranes, several thousand to several tens of thousands of hollow fiber membranes are bundled into a single bundle, and their ends are in some way fixed using adhesive

[1] Translator's note: SS = semisolids

in order to form a hollow fiber membrane element. These elements are then housed in a module container. Hollow fiber filtration membrane modules that are manufactured into the form of products are simply called "modules". A wide variety of forms have been proposed as hollow fiber filtration membrane modules that can filter liquids. In particular, filtration modules were initially proposed for use in combination with appropriate pre-treatment methods for purposes of reverse osmosis filtration, for dialysis applications, and so on. A wide variety of modules have been proposed for these various applications, and some of the principal examples are found cited in Patent Publications 48-28380 and Unexamined Patent Publications 49-69550, 53-100176, etc. These are all either disposable or embodiments which use chemically-treated water in order to clean or flush [the filters] after a certain amount of dirt builds up in them.

0004

On the other hand, there have been recent tests in which ways have been developed to shape a hollow fiber filtration membrane module and to periodically remove material adhering to the surface of the hollow fiber membrane with air, thereby recovering the functionality of the hollow fiber membrane. In Unexamined Patent Publication 61-263605, the hollow fiber membranes are formed into a U-shape and housed within a container. Air is periodically introduced into the bottom of the container through an air inlet orifice provided therein in order to perform air scrubbing which vibrates the hollow fiber membrane, thereby removing accumulations' on the membrane surface. Also, Unexamined Patent Publication 60-206415 discloses a module in which hollow fiber membranes are disposed around a central pipe which is then fitted into a container having a U-shape, as above, and wherein material that has built up upon the hollow fiber membrane surfaces is removed by means of air scrubbing. Studies are already under way toward the reduction of these technologies to practice.

0005

Furthermore, Unexamined Patent Publication 48-34763 discloses a method in which fine particles adhering to the membrane are peeled off with compressed air and backwashed with the filter liquid or with another liquid.

0006

**Problems the Invention is Intended to Resolve**

Air scrubbing and backwashing are good methods for the removal of accumulations on the hollow fiber membrane surfaces resultant from the processing of water with hollow fiber filter membrane modules, and it is possible to restore the filter more or less to its condition prior to filtration by removing (washing) the membrane surfaces with methods such as these, thereby recovering filter functionality and extending the service life of hollow fiber filter membrane modules in an economical fashion. However, most prior art air scrubbing methods involve the use of air jets only from the bottom of the module, and particularly in the case of large hollow fiber bundles, these methods do not allow the bubbles to get into the interior of the hollow fiber bundles, and only remove accumulated material near the surface of the hollow fiber bubbles. Methods have been proposed in which multiple holes are provided over the entire length [of the container] and use an air pressure line as in the case of Utility Model 3-15627, wherein air is introduced into the module container from locations other than the bottom of the container. Nevertheless, this method is defective because if the overall length of the module is long and there is a significant difference in water pressure between the top and bottom portions of the

module, it is virtually impossible to generate enough of the bubbles that are critical for washing because air tends to pool at the top of the module and be introduced into the module from the air holes and air pressure supply line holes near the top. Further, accumulated material that has been cleaned tends to build up in the vicinity of the air jet orifice at the bottom of the module container, causing clogging of the air jet orifices, and making it harder to clean the hollow fiber membranes. Therefore, there is a need for a module in which the entire hollow fiber membrane bundles in the elements can be cleaned and in which there is little clogging of the air jet orifices.

0007

**Means of Solving the Problems**

The goals of this invention are essentially achieved in a hollow fiber filter membrane element comprising an external pressure system that passes raw water from the outside through hollow fiber membrane bundles to the inside thereof to filter the same and remove the processed water from one end, an air inlet pipe in the central part of the hollow fiber membrane bundles, and wherein inlet air jet orifices from the outside are formed in the lower half of the total length of the element.

0008

In the hollow fiber filter membrane element and module of this invention, inasmuch as the single air scrubbing air jet orifice for the physical cleaning of the hollow fiber filter membrane element is provided within the fiber bundle, the membrane is effectively shaken inside of the fiber bundle resulting in a significant increase in the recovery of filter performance due to air scrubbing compared with prior art elements in which air scrubbing is done from the lower part of the element. Moreover, since the air jet orifice is provided inside an element that is periodically replaced, such problems as clogging of the air jet orifices can basically be handled by periodic replacement of the element, thereby contributing to improved maintenance characteristics of membrane treatment devices.

0009

The following detailed description of the invention is based on the drawings, but this invention is not limited to the drawings.

0010

Figure 1 shows an example of an element of this invention in which an air inlet orifice is provided near the lower end plate of the air inlet pipe provided in the center, and which is fitted into a module container. A module container lower air jet orifice as recited in Claim 5 is also provided at the bottom of the module container. The module container 1 cap can be removed to facilitate easy replacement of the element, and the element is installed in the container with sealing materials interposed. Moreover, the module container is provided with a raw water supply inlet 11 that supplies raw water, a drain orifice 12 that drains liquid in the module container, an air relief orifice 13, a processed water orifice 14, an air inlet orifice 15 that connects with the element air inlet pipe, and a module container lower air inlet orifice 16 that can be used in combination for air scrubbing from the lower portion of the module container. Furthermore, a hollow fiber membrane element to is housed within the module container.

0011

The hollow fiber membrane element is fixed in place on one end or both ends by adhesive. Figure 1 is an example of a hollow fiber membrane element that is fixed on both ends, and it has a lower end plate 22, upper end plate 23, and there are openings in one end plate for the hollow fibers, so that processed water can be removed. In the example shown in Figure 1, the hollow fiber membrane is open at the

upper end plate. Also, the top and the lower end plates are connected by an air inlet pipe 24, and the air inlet pipe is connected in an airtight way with the module container air inlet orifice.

0012

The example shown in Figure 1 has holes provided at the bottom of the air inlet pipe 24 that serve as air jet orifices 25, but slits may be used in place of the hole-shaped air jet orifices shown in Figure 1.

0013

Further, as shown in Figures 2 and 3, it is acceptable to provide air diffuser tubes that branch off from the air inlet pipe. Although the air diffuser tube effectively connects with the air inlet pipe perpendicularly, it may be connected within a range of angles off the perpendicular as long as this does not interfere with the effect of the invention. Also, it is preferable that the location of connection be below 1/4 the overall length of the element.

0014

While there are no particular limitations on the number and length of air diffuser tubes, there should be at least 2, preferably at least 3, and even more preferably 4 or more. If the hollow fiber membranes are divided into a number of membrane bundles, then the number should preferably be the same as the number of hollow fiber membrane bundles, or a multiple of the integers. With regard to length, they should preferably be more than 1/2 the radius of the element. The air jet orifice should preferably be about 1/2 the radius of the element.

0015

Otherwise, it is acceptable to configure [the air diffuser pipe] inside the lower end plate as shown in Figures 4 and 5, but these may also be provided in the air diffuser plate installed within the air inlet pipe, as shown in Figures 6 and 7. What is here called an air diffuser plate is something having an external shape that is the same as the bundling plate that bundles the hollow fiber membrane bundles. They have air jet orifices in their surface, and are structured so that the air that has been conducted from the air inlet pipe is ejected.

0016

These are examples of forms of [the invention], and the invention is not necessarily limited to these. In Figures, 2, 3, 4, and 5, the air jet orifices are located in between the hollow fiber membrane bundles where there are no hollow fibers, but there is no impediment to providing the air jet orifices near the inside of the hollow fiber membrane bundles.

0017

Figure 8 shows an example in which the air inlet orifices are located at the bottom of the module container, and the air inlet pipes are connected in an airtight way to the air inlet orifices at the bottom of the module container. Otherwise, it is the same as the example shown in Figure 1.

0018

Figure 9 shows an example of an application of the invention in which the hollow fiber membranes are formed into a U-shape to form an element with a take-off at one end.

0019

The hollow fiber filter membrane elements used here filter raw water through countless minute holes in the surface of the hollow fiber membrane, passing only pure water from which SS and fine particle components, debris, microorganisms, and so on have been removed, to the inside of the hollow fiber membrane, and filtered water is drawn off from the filtered water orifice. Hollow fiber membrane elements span a wide range of varieties and applications, including not only this sort of precision filtration or ultra-filtration, in which the hollow fiber membranes perform dialysis, reverse osmosis or materials trans-

fer between liquids, but also applications in materials transfer between liquids and gases, or for materials transfer between gases. Although it is common in filtration using hollow fiber membrane elements that the larger the volume of raw water filtered, the larger the volume of filtrate, as the filter is used over time, it is typical for the SS components, fine particles, etc. to build up on the membrane surface, more or less clogging the hollow fiber membrane mesh, and gradually reducing the amount of filtered water per unit of pressure. Thus, as clogging progresses, and when the reduction in the amount of filtered water reaches a certain point, cleaning operations are performed using backwashing or air scrubbing in order to recover the amount of filtered water nearly to levels before the clogging occurred.

0020

The ways in which modules into which hollow fiber filter membrane elements that have been fitted into modules can be used may be determined according to the needs of users, and there are no limitations on the ways in which they may be used. Some of the ways in which they may be operated include operation methods in which the amount of filtered water is varied at constant pressure, operation in which the amount of filtered water is kept constant while automatically or manually controlling pressure, or methods in which the module is attached to an appropriate raw water source and run at whatever the pressure and temperature happens to be.

0021

This invention is the result of thorough investigations conducted by the inventors into ways to improve the effectiveness of air scrubbing in the cleaning of hollow fiber filter membrane elements and into improvements in their maintenance properties in the cleaning of hollow fiber filter membrane elements.

0022

The form does not matter if the hollow fiber filter membrane element and module of this invention is a filter element using porous hollow fiber membrane bundles as its filter material. Preferred forms for the hollow fiber filter membrane element of this invention are structures in which holes are formed in the hollow fiber membrane by cutting one end of the adhesive seal area after both ends of the hollow fiber filter membrane bundle are sealed with adhesive. Also, it is typical for the element to be housed inside a module container. Although it is preferable for the element to be fitted into a module container with a sealing material interposed in between and able to be removed from the container at will, a structure may also be used in which the element is bonded with the container by means of adhesive, etc.

0023

As long as they are porous hollow fiber membranes, there are no particular constraints on the hollow fiber membrane material comprising the hollow fiber filter membrane element of this invention, but polyethylene, polypropylene, polysulfone, polyethylsulfone, polyvinyl alcohol, cellulose acetate, polyacrylonitrile, or other materials may be selected. Among these, as a particularly preferable material for a hollow fiber membrane, polymers containing acrylonitrile as at least one of its components are appropriate, given acrylonitrile's sufficient mechanical strength when subjected to air scrubbing. The most preferable acrylonitrile polymer is a single or two or greater copolymer of over 50 mole% acrylonitrile, and preferably over 60 mole% acrylonitrile versus under 50%, and more preferably 0–40 mole% single or 2 or greater vinyl compounds. Moreover, it is also acceptable for there to be other polymers in addition to these single or 2 or more acrylonitrile polymers. As for the above-mentioned vinyl com-

pounds, well-known compounds which are copolymers having acrylonitrile may acceptably be used and there are no particular limitations, but preferable copolymer compounds such as acrylic acid, itaconic acid, methacrylic acid, methacrylic acid methyl, polyvinyl acetate, allyl sulfonic acid soda, p-styrene sulfonic acid soda, among others can be mentioned.

0024

Further, the following materials are suitable for the hollow fibers: independents such as ethylene-propylene or 4-methyl pentene, or two or more olefinic polymers. A slit-shape long and narrow hole is appropriate for the hollow fiber membranes, with a long surface diameter of 0.1μm~10μm and a short diameter of 0.1~1.0μm.

0025

**Embodiments**

Embodiment 1

The hollow fiber membrane element of this invention has an outer diameter of 470 cm, and an inner diameter of 350 cm, and an average bore size of 0.01μm, consisting of 20,000 strands of polyacrylonitrile porous hollow fiber membrane, having air inlet pipes which have air jet orifices on both ends and which is fixed with urethane adhesive. After fixation [with urethane adhesive], the adhesive fixation parts at both ends are cut to form holes in the hollow fiber membrane. Filtration experiments were conducted with this element installed in a module container having a diameter of 17 cm and a length of 120 cm, forming a hollow fiber filter membrane module.

0026

The filtering experiments used raw water to which 5 ppm of poly aluminum chloride (PAC) were added, and automatic pressure adjustment was used to adjust the flow volume so that it was 8 liters/minute during filter processing. The pressure rises according to the degree of element clogging to maintain the desired flow volume. When the supply pressure reached 1.0 kgf/cm$^2$, back washing was performed using the processed water, and washing by means of air scrubbing was performed by introducing air through the air inlet pipes and from the bottom of the module, and normal operations were resumed after draining water to complete one cycle. Normal filtration was possible even after 1,000 hours had elapsed in these tests, and there was no accumulation of material either on the hollow fiber bundles inside or the lower end plates of the hollow fiber bundles.

0027

Embodiment 2

Experiments were performed as in Embodiment 1 with the exception that the hollow fiber membrane element was provided with air diffuser tubes connecting the air jet holes perpendicularly to the air inlet pipe as shown in Figures 2, 3. In these tests, normal filtering could be performed as in Embodiment 1 even after 1,000 hours had elapsed, and as in Embodiment 1, due to the effect of the air diffuser tubes, there was very little buildup of dirt on the hollow fiber membrane bundles in the vicinity of the lower end plate.

0028

Comparative Example 1

The hollow fiber filter membrane element and raw water, as well as the operating parameters were identical to those used before the embodiments, and air was supplied from the bottom of the module for air scrubbing in the same way as for prior art elements, and air was not supplied from air jet orifices in the element. After 1,000 hours had elapsed from the start of the experiment, the hollow fiber bundles, particularly in the vicinity of the lower end plate, were caked with accumulated material, and a decline in the usable membrane surface area was observed.

0029

**Effect of the Invention**

This invention significantly increases the recovery of filtering capacity by air scrubbing in hollow fiber filter membrane elements and modules that filter liquids containing fine particles and suspended materials. It is particularly effective when air jet orifices are disposed inside the hollow fiber membrane bundles by means of air diffuser tubes, air diffuser plates, and so on. Moreover, a hollow fiber filter membrane element and module are provided having enhanced maintenance properties.

**Brief Description of the Drawings**

Fig. 1 Vertical cross-section of an example of a module into which a hollow fiber filter membrane element of this invention provided with an element air inlet pipe and air jet means are fitted into a module container.

Fig. 2 A horizontal cross section of an example a module into which a hollow fiber filter membrane element of this invention provided with air diffuser tubes is fitted into a module container

Fig. 3 A vertical cross-section in the vicinity of the air jet orifices of an example a module with a hollow fiber filter membrane element of this invention provided with air diffuser tubes and fitted into a module container

Fig. 4 A horizontal cross-section in the vicinity of the air jet orifices of an example of a module into which a hollow fiber filter membrane element of this invention provided with air jet means in the lower end plate and which is fitted into a module container

Fig. 5 A vertical cross-section in the vicinity of the air jet orifices of an example of a module in which a hollow fiber filter membrane element of this invention provided with air jet means in the lower end plate and which is fitted into a module container

Fig. 6 A horizontal cross section of an example of the module in which a hollow fiber filter membrane element of this invention provided with air diffuser plate is fitted into a module container

Fig. 7 A vertical cross section of an example of the module in which a hollow fiber filter membrane element of this invention provided with air diffuser plate is fitted into a module container

Fig. 8 A vertical cross-section of an example of a hollow fiber filter membrane module provided with air jet means that the bottom of the module container of this invention

Fig. 9 A vertical cross-section of an example of this invention which is a module into which a U-shaped hollow fiber membrane element is fitted into the module container

Symbols

1 Module container
2 Hollow fiber membrane element
11 Raw water supply orifice
12 Drain orifice
13 Air relief orifice
14 Processed water orifice
15 Air inlet orifice
16 Module lower air inlet orifice
21 Hollow fiber membrane bundle
22 Lower end plate
23 Upper end plate
24 Air inlet pipe
25 Air jet orifice